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Assignee: Flarion Technologies, Inc.

Appl. Title: Signaling method in an OFDM multiple access system

Art Unit: 2600

Examiner: NGUYEN, Steven

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Mailed October 17, 2002

Boulder, CO 80303

Commissioner of Patents and Trademarks

Washington, District of Columbia 20231

Dear Sir,

The following prior-art references are submitted to the Examiner for consideration in the prosecution of Pat. Appl. No. 09/805,887, filed on 03/15/2001.

1. (Nassar et. al.) C. Nassar, B. Natarajan, S. Shattil, "Introduction of Carrier Interference to Spread Spectrum Multiple Access," Proceedings of the *IEEE Emerging Technologies Symposium on Wireless Communications and Systems*, Dallas, TX, April 12-13, 1999.
2. (Shattil01) S. Shattil, "Multiple Access Method and System," PCT Appl. No. PCT/US99/02838, International Publication No. WO 99/41871, 08/19/1999.
3. (Shattil02) S. Shattil, C. Nassar, "Array Control Systems for Multicarrier Protocols Using a Frequency-Shifted Feedback Cavity," Proceedings of the *1999 IEEE Radio and Wireless Conference*, Denver, CO, August 1-4, 1999.

The prior-art references, Shattil01, Shattil02, and Nassar et. al., invalidate the independent patent claims, and thus, the dependent patent claims in Pat. Appl. No. 09/805,887.

The prior-art references, Shattil01, Shattil02, and Nassar et. al., are printed publications that were available to the public more than one year before the priority date of 09/13/2000 claimed by Pat. Appl. No. 09/805,887, filed on 03/15/2001.

Furthermore, combinations of the prior-art references, Shattil01, Shattil02, and Nassar et. al., are obvious combinations because they relate to multicarrier communications, and more specifically to Carrier Interference Multiple Access (CIMA) communications.

The prior-art references, Shattil01, Shattil02, and Nassar et. al., describe methods and systems adapted to transmit information-modulated pulse waveforms generated from a superposition of orthogonal carriers, such as described and claimed in Pat. Appl. No. 09/805,887.

In particular, Shattil01 describes providing a predetermined number of carriers having a frequency separation and symbol period selected to ensure orthogonality (page 4, lines 25-34). The carriers may include contiguous carrier frequencies or uniformly spaced frequencies distributed over a broad frequency band, such as shown in FIG. 12A and FIG. 8, and described on page 7, line 33 to page 8, line 7. The carriers are provided with phase offsets to produce pulse waveforms centered at predetermined time instants (such as described on page 2, lines 32-36, page 5, lines 1-4, page 5, line 28 to page 6, line 27, and page 7, lines 27-32, and shown in FIGs. 4, 5B, and 12B). For a number N of carriers, there are N orthogonal phase spaces (i.e., pulse positions), such as described on page 7, lines 24-29, and expressed mathematically on page 6, lines 4-11. Each user may be allocated a unique set of carriers (such as described on page 7, lines 27-29 and page 12, lines 3-8). FIG. 12A shows 20 carrier frequencies allocated to a particular user, and FIG. 12B shows 20 pulses orthogonally positioned in time corresponding to data transmitted and/or received by that user. If complex (e.g., QPSK) data symbols are transmitted, the quadrature-phase components overlap the in-phase components (i.e., pulses), such as shown in FIG. 12B. The carriers are modulated with data symbols (such as described on page 4, lines 25-28) such that each data symbol is mapped to a pulse centered at a

predetermined instant in time. Multicarrier transmitter methods and systems are described with respect to FIGs. 1 and 2.

Shattil02 (Figure 3, page 3, column 1, line 9 to page 3, column 2, line 3) illustrates a system and method for generating a multicarrier signal adapted to produce a superposition signal characterized by a sequence of interferometry pulses that are orthogonal in the time domain. Data symbols are mapped onto pulse waveforms (such as illustrated by equation 2 and shown in Figure 4) that include sinusoids allocated to one or more users. The pulses are positioned orthogonally in time, thus mapping each data symbol to one of a plurality of equally spaced instants in time.

Nassar et. al. describes CIMA, a multicarrier transmission protocol that is related to OFDM and multicarrier-CDMA signaling (page 1, column 1, line 2 to page 2, column 1, line 10). The carrier frequency spacing Δf and data symbol period $T_b = 1/\Delta f$ are selected to ensure orthogonality between the carriers (page 3, column 1, lines 8-13). The number of users in an orthogonal CIMA system is less than or equal to the number N of carriers (page 1, column 2, line 33 to page 2, column 1, line 3). A superposition of in-phase carriers produces a time-domain pulse-shaped waveform, as described on page 2, column 1, lines 20-35, and expressed mathematically by equations 1 and 2. Predetermined sets of phase offsets are provided to the carriers to position the pulses orthogonally in time, as described on page 2, column 1, line 36 to page 2, column 2, line 2. The cross correlation between the pulse waveforms (shown in equations 4 and 5 and described on page 2, column 2, lines 5-22) indicates that there are N orthogonal pulse positions (i.e., time instants) distributed evenly throughout each symbol period T_b. The cosine term in equation 5 (explained on page 2, column 2, lines 14-19) illustrates a second (pseudo-orthogonal) set of evenly spaced pulse positions that may be used to transmit N additional real data symbols. The orthogonal and pseudo-orthogonal pulse positions correspond to in-phase and quadrature-phase parts of complex signals, respectively. Thus, each complex data symbol modulated onto the carriers is characterized by one of the orthogonal pulse positions and one of the pseudo-orthogonal pulse positions. Data symbols are modulated onto the carriers, or equivalently, onto the pulses. Each pulse

reflects the value of a particular data symbol assigned to that pulse position, as described on page 2, column 2, line 36 to page 3, column 1, line 3. In a frequency-division multiplex system (such as described in Shattil01, on page 7, lines 27-29 and page 12, lines 3-8) in which each user is assigned a unique set of carriers, a user's transmitted signal may be expressed as the signal shown in equation 7, wherein K is the number of pulse positions per symbol period T_b. Multicarrier transmitter methods and systems are described with respect to Figure 4.

35 U.S.C. 102 Conditions for patentability; novelty and loss of right to patent.

A person shall be entitled to a patent unless -

(a) the invention was known or used by others in this country, or patented or described in a printed publication in this or a foreign country, before the invention thereof by the applicant for patent, or

(b) the invention was patented or described in a printed publication in this or a foreign country or in public use or on sale in this country, more than one year prior to the date of the application for patent in the United States, or

(e) the invention was described in-

(1) an application for patent, published under **section 122(b)**, by another filed in the United States before the invention by the applicant for patent, except that an international application filed under the treaty defined in **section 351(a)** shall have the effect under this subsection of a national application published under **section 122(b)** only if the international application designating the United States was published under **Article 21(2)(a)** of such treaty in the English language.

The independent patent claims in Pat. Appl. No. 09/805,887 read on the prior-art references, Shattil01, Shattil02, and Nassar et. al. The prior-art references were available more than one year before the priority date claimed by Pat. Appl. No. 09/805,887.

Elements recited in independent Claim 1 were first described in Shattil01 in the disclosure related to FIGs. 1 and 2.

The plurality of carrier mixers 14n is an allocation circuit that provides carrier frequencies used to generate at least one superposition signal for a particular user. The plurality of phase-shift/delay systems 16n is a mapping circuit that maps each data symbol from the data source 12 to a predetermined instant in time. Each set of phase shifts applied to the information-modulated carriers by the phase-shift/delay system 16n produces a phase alignment of the carriers (i.e., an interference pulse) at the predetermined instant in time. Thus, the combination of the phase-shift/delay systems 16n and the data source 12 produces a discrete signal of the mapped data symbols. The combining system 20 functions as an interpolation circuit because it combines the phase shifted carriers to produce one or more information-modulated pulses centered at the predetermined instants in time. Multiple pulses may be distributed throughout each data symbol interval. The frequency response of the pulses includes sinusoids provided by the carrier mixers 14n (i.e., allocation circuit).

A sampling circuit, such as the sampling circuit recited in Claim 1, is commonly used in prior art digital communication transmitters. Thus, the sampling circuit is not a novel element in Claim 1. For example, B. Sklar illustrates a formatting system (Figure 2.2) in a digital communication transmitter that includes a sampling circuit. Various types of information signals, including analog (i.e., continuous) signals, are formatted prior to being coupled to a waveform encoder (i.e., a modulator). Formatting analog signals includes sampling the signals in order to generate a sequence of binary bits. Then the bits are mapped to a constellation of modulation symbols (e.g., phase shift key, amplitude shift key, or quadrature amplitude shift key symbols) in a modulator (such as described on page 54, lines 4-22 and page 55, lines 17-33). Further descriptions of formatting analog signals are disclosed on page 59, line 6 to page 70, line 19.

Elements recited in independent Claim 17 were first described in Shattil01 in the disclosure related to FIGs. 1 and 2.

The plurality of phase-shift/delay systems 16n is a mapping module that maps each data symbol from the data source 12 to a predetermined instant in time. The phase-shift/delay system 16n applies one or more sets of phase offsets to a plurality of carriers, which are provided by the plurality of carrier mixers 14n and modulated with one or more data symbols. Each set of phase offsets produces a phase alignment of the carriers (i.e., an interference pulse) at a predetermined instant in time. Each phase alignment maps a data symbol to an instant in time. Thus, the combination of the phase-shift/delay systems 16n and the data source 12 produces a discrete signal consisting of the mapped data symbols. The carrier mixers 14n and the combining system 20 together function as an interpolation module (as described in Claim 17). The combining system 20 combines the phase-shifted carriers to produce one or more information-modulated pulses centered at the predetermined instants in time. The carrier mixers 14n provide the carriers from which the pulses are produced. Thus, the frequency response of the pulses includes only the sinusoids allocated by the carrier mixers 14n to a particular user.

Elements recited in independent Claim 25 were first described in Shattil01 in the disclosure related to FIGs. 1 and 2.

The plurality of phase-shift/delay systems 16n is a mapping module that maps each data symbol from the data source 12 to a predetermined instant in time. The phase-shift/delay system 16n applies phase offsets to a plurality of carriers, which are provided by the plurality of carrier mixers 14n and modulated with one or more data symbols. Each set of phase offsets produces a phase alignment of the carriers (i.e., an interference pulse) at a predetermined instant in time, thus, mapping each data symbol to an instant in time. The combination of the phase-shift/delay systems 16n and the data source 12 produces a discrete signal consisting of the mapped data symbols. The carrier mixers 14n and the combining system 20 together function as an interpolation module, which is described in Claim 25. The combining system 20 combines the phase-shifted carriers to produce one

or more information-modulated pulses centered at the predetermined instants in time. The carrier mixers 14n provide the carriers from which the pulses are produced. Thus, the frequency response of the pulses includes only the sinusoids allocated by the carrier mixers 14n to a particular user.

The carrier mixers 14n and the combining system 20, as well as other components in the transmitter, may be implemented as digital signal processing components, such as described in Shattil01, page 5, lines 16-18. Consequently, the information-modulated pulses generated by the carrier mixers 14n and combining system 20 may be a digital signal sample vector.

The set of elements recited in independent Claim 29 were first described in Shattil01 in the disclosure related to FIGs. 1 and 2.

The plurality of phase-shift/delay systems 16n is a mapping module that maps each data symbol from the data source 12 to a predetermined instant in time. The phase-shift/delay system 16n applies one or more sets of phase offsets to a plurality of carriers, which are provided by the plurality of carrier mixers 14n and modulated with one or more data symbols. Each set of phase offsets produces a phase alignment of the carriers (i.e., an interference pulse) at a predetermined instant in time, and thus, effectively maps each data symbol to an instant in time. Thus, the combination of the phase-shift/delay systems 16n and the data source 12 produces a discrete signal of the mapped data symbols. The carrier mixers 14n and the combining system 20 together function as an interpolation module, as described in Claim 29. The combining system 20 combines the phase shifted carriers to produce information-modulated pulses centered at the predetermined instants in time. Since the pulses are positioned orthogonally in time if the phase offsets are appropriately selected (such as shown in FIG. 12B in Shattil01, and described in Nassar et. al. on page 2, column 1, line 36 to page 2, column 2, line 2), signal characteristics (e.g., phase, amplitude, frequency, etc.) of each pulse at the pulse maxima conveys the data symbol value assigned to the corresponding phase space (i.e., instant in time at which the pulse is centered).

Elements recited in independent Claim 30 were first described in Shattil01 in the disclosure related to FIGs. 1 and 2.

The plurality of phase-shift/delay systems 16n is a mapping circuit that maps each data symbol from the data source 12 to a predetermined instant in time. The phase-shift/delay system 16n applies sets of phase offsets to carriers. The carriers are provided by the plurality of carrier mixers 14n and optionally modulated with one or more data symbols. Each set of phase offsets produce a phase alignment of the carriers (i.e., an interference pulse) at a predetermined instant in time, thus, mapping each data symbol to an instant in time. The combination of the phase-shift/delay systems 16n and the data source 12 produces a discrete signal of the mapped data symbols. The carrier mixers 14n and the combining system 20 together function as an interpolation circuit (as described in Claim 25). The combining system 20 combines the phase shifted carriers to produce one or more information-modulated pulses centered at the predetermined instants in time. The carrier mixers 14n provide the carriers from which the pulses are produced. Thus, the frequency response of the pulses includes only the sinusoids allocated by the carrier mixers 14n to a particular user. Since each user may be assigned a unique set of carriers (such as described in Shattil01 on page 7, lines 27-29 and page 12, lines 3-8), the pulse waveforms produced by the communication system can include non-zero sinusoids allocated to a particular user and zero-valued (i.e., absence of) sinusoids allocated to other users.

Elements recited in independent Claim 41 were first described in Shattil01 in the disclosure related to FIGs. 1 and 2.

The plurality of phase-shift/delay systems 16n is a mapping circuit that maps each data symbol from the data source 12 to a predetermined instant in time. The phase-shift/delay system 16n applies sets of phase offsets to a plurality of carriers. The carriers are provided by the plurality of carrier mixers 14n and modulated with one or more data symbols. Each set of phase offsets produces a phase alignment of the carriers (i.e., an

interference pulse) at a predetermined instant in time, thus, mapping each data symbol to an instant in time. The combination of the phase-shift/delay systems 16n and the data source 12 produces a discrete signal of the mapped data symbols. The carrier mixers 14n and the combining system 20 together function as an interpolation circuit (as described in Claim 41). The combining system 20 combines the phase shifted carriers to produce one or more information-modulated pulses centered at the predetermined instants in time. The carrier mixers 14n provide the carriers from which the pulses are produced. Thus, the frequency response of the pulses includes only the sinusoids allocated by the carrier mixers 14n to a particular user. Since each user may be assigned a unique set of carriers (such as described in Shattil01 on page 7, lines 27-29 and page 12, lines 3-8), the pulse waveforms produced by the communication system can include non-zero sinusoids allocated to a particular user and zero-valued (i.e., absence of) sinusoids allocated to other users.

The carrier mixers 14n and the combining system 20, as well as other components in the transmitter, may be implemented with digital signal processing components, such as described in Shattil01, page 5, lines 16-18. Consequently, the information-modulated pulses generated by the carrier mixers 14n and combining system 20 may be a digital signal sample vector.

Elements recited in independent Claim 45 were first described in Shattil01 in the disclosure related to FIGs. 1 and 2.

The plurality of phase-shift/delay systems 16n is a mapping circuit that maps each data symbol from the data source 12 to a predetermined instant in time. The phase-shift/delay system 16n applies sets of phase offsets to a plurality of carriers, which are provided by the plurality of carrier mixers 14n and modulated with one or more data symbols. Each set of phase offsets produces a phase alignment of the carriers (i.e., an interference pulse) at a predetermined instant in time, and thus, maps each data symbol to an instant in time. The combination of the phase-shift/delay systems 16n and the data source 12 produces a discrete signal of the mapped data symbols. The carrier mixers 14n produce a set of

carriers allocated to a particular user, and thus, perform the same function as a Discreet Fourier Transform (DFT) circuit combined with a zero-insertion circuit. For example, the transmitter shown in Shattil01 in FIGs. 1 and 2 may be implemented with DFTs, such as described on page 5, lines 16-18. The combining system 20 combines the modulated, phase-shifted carriers to produce information-modulated pulse waveforms. These pulse waveforms are inverse Fourier transforms of the carriers represented in the frequency domain, as described on page 5, lines 28-31. Thus, the combining system performs the same function as an Inverse-DFT circuit.

The use of DFT-based filters, such as the so-called zero-insertion circuit, is well known in the art. H. Bolcskei et. al., "Equivalence of DFT Filter Banks and Gabor Expansions," SPIE Proc. Vol. 2569, "Wavelet Applications In Signal and Image Processing III," San Diego, CA, July 1995, shows DFT filter banks (page 4, line 9 to page 6, line 10), including an analysis/synthesis filter bank combination, which is a windowing system, such as a zero-insertion circuit. An example of a DFT-based filter adapted to perform zero insertion in an OFDM system is shown in Fig. 4 of J. Armstrong, "PCC-OFDM with Reduced Peak-to-Average Power Ratio."

Elements recited in independent Claim 50 were first described in Shattil01 in the disclosure related to FIGs. 1 and 2.

The combination of the carrier mixers 14n and the phase-shift/delay system 16n provides a symbol duration T_b having equally spaced time instants. For a number N of carriers, there are N orthogonal phase spaces (i.e., pulse positions) in a symbol interval T_b, such as described on page 7, lines 24-29, and expressed mathematically on page 6, lines 4-11. Each user may be allocated a unique set of carriers (such as described on page 7, lines 27-29 and page 12, lines 3-8). FIG. 12A shows 20 carrier frequencies allocated to a particular user, and FIG. 12B shows 20 pulses orthogonally (and equally) positioned in time corresponding to data transmitted by that user. In Nassar et. al., predetermined sets of phase offsets are provided to the carriers to position the pulses orthogonally in time, as described on page 2, column 1, line 36 to page 2, column 2, line 2. The cross correlation

between the pulse waveforms (shown in Nassar et. al., equations 4 and 5 and described on page 2, column 2, lines 5-22) indicates that there are N orthogonal pulse positions (i.e., time instants) distributed evenly throughout each symbol period T_b.

The carrier mixers 14n provide a predetermined set of orthogonal carrier frequencies allocated to the transmitter. The data source 12 provides data symbols to be transmitted in a multicarrier transmission signal. The plurality of phase-shift/delay systems 16n maps each data symbol from the data source 12 to a predetermined instant in time. The phase-shift/delay system 16n applies sets of phase offsets to the N carriers, which are provided by the plurality of carrier mixers 14n and modulated with one or more data symbols. Each set of phase offsets produces a phase alignment of the carriers (i.e., an interference pulse) at a predetermined instant in time, thus, mapping each data symbol to an instant in time. The combination of the phase-shift/delay systems 16n and the data source 12 produces a discrete signal of the mapped data symbols. The combining system 20 provides an interpolation function to the data symbols mapped to equally spaced instants in time because it combines the phase-shifted carriers to produce one or more information-modulated pulses centered at the predetermined instants in time. Multiple pulses may be distributed throughout each data symbol interval (such as shown in FIG. 12B), thus reducing the signal's peak-to-average power. The frequency response of the pulses includes sinusoids provided by the carrier mixers 14n. Since each user may be assigned a unique set of carriers (such as described in Shattil01 on page 7, lines 27-29 and page 12, lines 3-8), the pulse waveforms produced by the communication system can include non-zero sinusoids allocated to a particular user and zero-valued (i.e., absence of) sinusoids allocated to other users.

A sampling circuit, such as the sampling circuit recited in Claim 50, is commonly used in prior art digital communication transmitters. Thus, the sampling circuit is not a novel element in Claim 1. For example, B. Sklar illustrates a formatting system (Figure 2.2) in a digital communication transmitter that includes a sampling circuit. Various types of information signals, including analog (i.e., continuous) signals, are formatted prior to being coupled to a waveform encoder (i.e., a modulator). Formatting analog signals

includes sampling the signals in order to generate a sequence of binary bits. The bits are then mapped to a constellation of modulation symbols (e.g., phase shift key, amplitude shift key, or quadrature amplitude shift key symbols) in a modulator (such as described on page 54, lines 4-22 and page 55, lines 17-33). Further descriptions of formatting analog signals are on page 59, line 6 to page 70, line 19.

Elements recited in independent Claim 67 were first described in Shattil01 in the disclosure related to FIGs. 1 and 2.

The carriers may include uniformly spaced frequencies distributed over a predetermined frequency band, such as shown in FIG. 8 and FIG. 12A, and described on page 7, line 33 to page 8, line 7. The carrier mixers 14n provide a predetermined set of carrier frequencies to be allocated to the transmitter. Selection of the frequency separation f_s between carriers defines the symbol duration T_b, where $T_b = 1/f_s$. The number of orthogonal pulse positions, which are equally spaced time instants in each symbol duration T_b, equals the number N of carriers. Thus, the selection of N defines the spacing of the time instants. The data source 12 provides data symbols to be transmitted in a multicarrier transmission signal. The phase-shift/delay systems 16n map each data symbol to a predetermined instant in time. The phase-shift/delay systems 16n applies sets of phase offsets to the N carriers, which are modulated with one or more of the data symbols. Each set of phase offsets produce a phase alignment of the carriers (i.e., an interference pulse) at a predetermined instant in time, thus, mapping each data symbol to an instant in time. Thus, the combination of the phase-shift/delay systems 16n and the data source 12 generates a discrete signal in the time domain.

The combining system 20 provides an interpolation function to the data symbols mapped to equally spaced instants in time because it combines the phase-shifted carriers to produce one or more information-modulated pulses centered at the predetermined instants in time. Multiple pulses may be distributed throughout each data symbol interval, thus reducing the signal's peak-to-average power. The frequency response of the pulses includes sinusoids provided by the carrier mixers 14n. Since each user may be assigned a

unique set of carriers (such as described in Shattil01 on page 7, lines 27-29 and page 12, lines 3-8), the pulse waveforms produced by the communication system can include non-zero sinusoids allocated to a particular user and zero-valued (i.e., absence of) sinusoids allocated to other users.

Since the prior-art references, Shattil01, Shattil02, and Nassar et. al., invalidate the independent patent claims, the dependent patent claims in Pat. Appl. No. 09/805,887 are also invalidated.

Furthermore, combinations of the independent claims and dependent claims are not novel. The dependent patent claims in Pat. Appl. No. 09/805,887 read on prior-art references Shattil01, Shattil02, and Nassar et. al., as well as other well known prior-art references dated more than one year before the priority claimed by 09/805,887.

The dependent claims in Pat. Appl. No. 09/805,887 read on prior-art references that were published more than one year before the claimed priority date. Since these references all relate to the field of multicarrier transmission protocols, and the combinations of the independent and dependent claims do not contradict what is well known in the art, there are no non-obvious combinations of the independent and dependent claims.

1. With respect to dependent claims 2, 39, and 51, Nassar et. al. describes the spacing of the pulse positions (i.e., time instants) corresponding to zeroes in the cross-correlation function (shown in equation 5 and described on page 2, column 1, line 36 to page 2, column 2, line 26). The pulses are centered at equally spaced instants: $k/N\Delta f$ where $k = 0,2,\ldots,N-1$, N is the number of carriers, and $\Delta f = 1/T_b$ is the frequency separation between the carriers. Thus, the time instants are defined by 0, T_b/N, $2T_b/N,\ldots, T_b(N-1)/N$.

2. With respect to dependent claims 3, 19, 52, and 68, Shattil01 (page 4, lines 28-34) describes the use of contiguous carrier frequencies in a transmitter. FIG. 5A illustrates contiguous carrier frequencies. For example, a symbol interval illustrated by the pulse

repetition period in FIG. 5B is represented by a 180-degree rotation along the wave fronts shown in FIG. 5A. In this case, there is a one-period difference between adjacent carriers over 180 degrees of arc (i.e., one symbol interval, T_b). This makes the carriers contiguous.

Each time instant corresponds to where a pulse can be centered. Nassar et. al. (page 2, column 1, line 19 to page 2, column 2, line 26) shows that a plurality of pulses equal to the number of carriers can be positioned orthogonally at uniformly spaced instances in each symbol duration. A symbol duration T_b equals the inverse of the frequency spacing Δf between the carriers. The time instants are spaced apart at intervals of T_b/N.

3. With respect to dependent claims 4, 5, 20, 21, 53, and 69, Shattil01 (FIG. 8 and page 7, line 33 to page 8, line 7) shows equally spaced carrier frequencies distributed over a predetermined frequency band. Since the carriers in a set of non-adjacent carrier frequencies are separated by an integer multiple L of the adjacent carrier frequency separations f_s, the frequency spacing f_s' in the set of non-adjacent carriers is: $f_s' = Lf_s$. Thus, the effective symbol duration T' (i.e., pulse repetition period) of the non-adjacent carriers is a fraction 1/L of the symbol period $1/f_s$, such as described on page 5, lines 34-35, and represented by equation $T' = T_b/L$.

4. With respect to dependent claims 6, and 49, Nassar et. al. (page 1, column 2, line 33 to page 2, column 1, line 3) describes a multicarrier systems in which a number of users (i.e., pulse positions) may be greater than the number of carriers.

5. With respect to dependent claims 7, 23, 26, 34, 42, and 66, U.S Pat. No. 5,491,727 (column 6, line 31 to column 15, line 29) describes a lookup table of sine values and a table of envelope (i.e., pulse) functions stored in memory and used to generate signals for transmission in a multi-tone communication system.

6. With respect to dependent claims 8, 27, 28, 36, 37, 43,and 44, the carrier mixers 14n and the phase/delay systems 16n shown in Shattil01 (FIGs. 01 and 02) together illustrate an NXK matrix of sinusoids, where N is the number of sinusoidal carriers (i.e., rows of the matrix) and K is the number of phase offset vectors (i.e., matrix columns) applied to the carriers. In particular, equation 7 described in Nassar et. al. on page 3, column 1, lines 4-10, illustrates an NXK matrix of sinusoids. Alternatively, a matrix of sinusoids may include a vector of sinusoids, wherein each sinusoid consists of a vector of digital values. The equation on page 6, line 6 in Shattil01 and equations 6 and 7 in Nassar et. al. each illustrate a matrix of sinusoids. In particular, a digital representation of matrix $e(t)=\sum e^{i(\omega_c+n\omega_s)t+n\Delta\phi}$, as suggested on page 5, lines 16-18, can be a matrix of sinusoids.

   Nassar et. al. illustrates a multiplication of a matrix of sinusoids by a vector of data symbol values in equation 7, which is described on page 3, column1, lines 4-10. Shattil01 implies multiplication between a matrix of sinusoidal carriers (represented by the equation on page 6, line 6) and a vector of data symbols on page 4, lines 26-27.

7. With respect to dependent claims 9 and 16, the generation of continuous, or analog, transmission waveforms (i.e., interpolation functions) is well known in the prior art. For example, digital-to-analog converters are commonly used to generate an analog signal from a vector of digital values, such as illustrated in FIG. 3 of U.S Pat. No. 5,491,727.

8. With respect to dependent claims 10, 11, 24, 35, 54, and 55, the generation of a continuous function via interpolating a series of symbols with a sinc function is a well-known aspect of the Nyquist Sampling Theorem applied to a band-limited signal. For example, this aspect of the Nyquist theorem is described in J G Daugman, "Continuous Mathematics, Computer Science Tripos Part IB," University of Cambridge, Term 1999. Furthermore, Shattil01 expresses the use of sinc pulse waveforms on page 11, lines 17-18 and shows a sinc-form equation representing a

pulse shape on page 6, line 8. Similarly, Nassar et. al. shows a sinc function in equation 2 (page 2, column 1, line 27) and Figure 1.

9. With respect to dependent claims 12, 40, and 70, the implementation of complex data modulation schemes in OFDM systems is well known. For example, in U.S. Pat. No. 5,406,551, column 1, lines 27-44, Quadrature Phase Shift Key (QPSK) modulation and Quadrature Amplitude Modulation (QAM) are described with respect to modulation techniques used in OFDM systems.

10. With respect to dependent claim 13, various components in the transmitter may be implemented with digital signal processing components, such as described in Shattil01, page 5, lines 16-18.

11. With respect to dependent claims 14, 15, 62, and 63, the use of a cyclic prefix in OFDM communications is well known. For example, in J. van de Beek, "On Synchronization in OFDM Systems Using the Cyclic Prefix," Proc. Radio Vetenskaplig Koferens, pp. 663-667, June 1996, (Part 2, The OFDM system Model) cyclic prefixes in common Discreet Multitone Systems consist of a copy of a number of samples at the end of a symbol being prepended to the beginning of the symbol.

12. With respect to dependent claims 18, and 32, it is well known that frequency division multiplexing may be provided for multiple access in a multicarrier system, such as an OFDM system. In Shattil01, each user may be allocated a unique set of carriers (such as described on page 7, lines 27-29 and page 12, lines 3-8). FIG. 8 (page 7, lines 33-35) and FIG. 12A show carrier frequencies allocated to a particular user.

13. With respect to dependent claim 22, Shattil01 describes a plurality of carriers provided with phase offsets to produce pulse waveforms centered at predetermined time instants (such as described on page 2, lines 32-36, page 5, lines 1-4, page 5, line 28 to page 6, line 27, and page 7, lines 27-32, and shown in FIGs. 4, 5B, and 12B). The carriers are modulated with data symbols (such as described on page 4, lines 25-

28) such that each data symbol is mapped to a pulse centered at a predetermined instant in time. Thus the values of the data-modulated pulses at the pulse peak (i.e., time instances at which the pulses are centered) equal the value of the data symbol corresponding to the pulse position.

14. With respect to dependent Claim 31, Shattil01 describes providing a predetermined number of carriers having a frequency separation and symbol period selected to ensure orthogonality (page 4, lines 25-34). Similarly, Nassar et. al. discloses a multicarrier signal with carrier frequency spacing Δf and data symbol period $T_b = 1/\Delta f$ selected to ensure orthogonality between the carriers (page 3, column 1, lines 8-13).

15. With respect to dependent Claim 33, the inclusion of a transmitter to a multicarrier signal generator is well known. For example, Shattil01 shows a frequency up-converter and antenna coupled to a multicarrier signal generator in FIGs. 1 and 2, which is described on page 5, lines 9-11. In Nassar et. al., it is understood that the multicarrier signal generated by the system shown in Figure 4 is transmitted into a communication channel, as suggested by discussions of propagation channel models associated with performance plots in Figures 7 and 8.

16. With respect to dependent Claim 38, the inclusion of a sampling circuit for processing an analog signal in a digital transmitter to produce a digital signal is well known. For example, B. Sklar illustrates a formatting system (Figure 2.2) in a digital communication transmitter that includes a sampling circuit. Various types of information signals, including analog (i.e., continuous) signals, are formatted prior to being coupled to a waveform encoder (i.e., a modulator). Formatting analog signals includes sampling the signals in order to generate a sequence of binary bits. Then the bits are mapped to a constellation of modulation symbols (e.g., phase shift key, amplitude shift key, or quadrature amplitude shift key symbols) in a modulator (such as described on page 54, lines 4-22 and page 55, lines 17-33). Further descriptions of formatting analog signals are disclosed on page 59, line 6 to page 70, line 19.

17. With respect to dependent Claims 46, 47, 48, and 65, Shattil01 (page 5, lines 4-6, and page 13, lines 7-9) describes applying a frequency-domain window to the multicarrier signal. U.S. Pat. No. 5,955,992, which is incorporated by reference in Shattil01, describes a variety of tapered-amplitude windows (including Hanning windows, which is a class of cosine roll-off windows) that may be applied to the carriers in the frequency domain. Raised cosine windows are one type of windowing function that is well known in the art, such as described in U.S. Pat. No. 5,768,308, column 6, lines 50-62. The Nyquist zero intersymbol interference criteria is the orthogonality criteria described in Nassar et. al. (page 2, column 1, line 36 to page 2, column 2, line 35) with respect to the cross correlation of CIMA pulses. The Nyquist zero intersymbol interference criteria requires a waveform to have zero crossings corresponding to positions of other waveforms. In J. Armstrong, "Analysis of New and Existing Methods of Reducing Intercarrier Interference Due to Carrier Frequency Offset in OFDM," IEEE Trans. Comm., Vol, 47, No. 3, March 1999, windowing systems are shown (Figures 4a and 4b) for an OFDM transmitter. Some of the window coefficients may be zero (such as described on page 367, column 2, line 43 to page 368, column 2, line 15) and may include windows adapted to satisfy the Nyquist criteria (page 367, column 2, lines 43-45). H. Bolcskei et. al., "Equivalence of DFT Filter Banks and Gabor Expansions," SPIE Proc. Vol. 2569, "Wavelet Applications In Signal and Image Processing III," San Diego, CA, July 1995, shows DFT filter banks (page 4, line 9 to page 6, line 10), including an analysis/synthesis filter bank combination, which is a windowing system, such as a zero-insertion circuit. An example of a DFT-based filter adapted to perform zero insertion in an OFDM system is shown in Fig. 4 of J. Armstrong, "PCC-OFDM with Reduced Peak-to-Average Power Ratio."

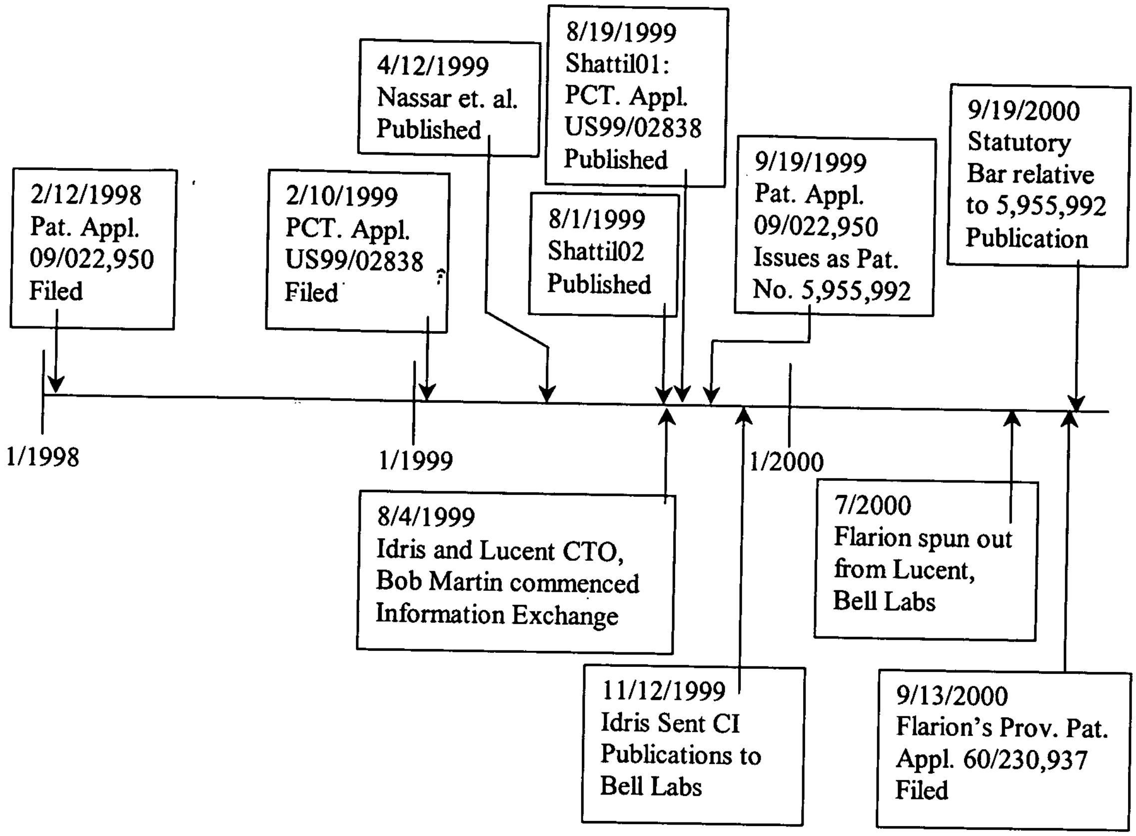
18. With regard to dependent Claims 56, 57, 58, 59, 60, 61, 71, 72, and 73, it is well known to provide relative phase offsets, such as phase offsets equal to $\pi/4$, to adjacent time-domain symbols for the purpose of reducing peak-to-average power of the transmitted signal. This is known in the art as Offset Quadrature Phase Shift Keying

(OQPSK). For example, H. Abut, "Digital Communications for Emerging Systems" course notes, August 6-8, 1997, describes OQPSK systems in Chapter 4, Section 3. Pages 4-7 of Chapter 4, Section 3 shows $\pi/4$-QPSK. Quadra "Electromagnetic Compatibility Aspects of Radio-based Mobile Telecommunications Systems - Final Report," Produced in 1999 for the LINK Personal Communications Programme by ERA Technology Ltd, (page D3, line 8 to page D4, line 9) describes delaying an odd bit stream with respect to an even bit stream in an OQPSK system.

Thus, it has been shown that both the independent claims and the dependent claims read on signal-processing techniques that are already well known in the art.

The invention described in Pat. Appl. No. 09/805,887, assigned to Flarion Technologies, is similar to technologies disclosed by Idris Communications, Inc. to Lucent and Bell Laboratories prior to Lucent spinning off Flarion Technologies, and more than one year prior to the priority date claimed by Pat. Appl. No. 09/805,887.

The following timeline summarizes relevant filing and publication dates establishing priority dates and statutory bar dates. Also included in the timeline are dates establishing the period of information exchange between Idris Communications, Inc. and Lucent/Bell Labs, and the spin off of Flarion Technologies, Inc. from Lucent. As illustrated by the time line, the filing of Provisional Pat. Appl. No. 60/230,937 may have been made to avoid a statutory bar resulting from the publication of U.S. Pat. No. 5,955,992.



The following information about the information exchange between Idris Communications, Inc. and Lucent/Bell Labs prior to Lucent Bell Labs spinning of Flarion Technologies is provided here as a matter of record. Idris Communications is a licensee of U.S. Pat. No. 5,955,992 and PCT Appl. No. PCT/US99/02838. Arnold Alagar, Chief Operating Officer of Idris Communications, met Robert Martin, Chief Technology Officer of Lucent Technologies, at the Disruptive Innovations Conference in Memphis Tennessee in July, 1999.

Lucent and Idris Communications continued conversations to explore establishing a business partnership to commercialize technologies being developed by Idris, including Carrier Interferometry. Information exchanges between Idris and Lucent included Idris supplying Lucent with copies of papers published at conferences on Carrier Interferometry, papers published on the Idris website, and issued U.S. patents (including U.S. Pat. No. 5,995,992). No dates of publication were indicated on the papers published

at conferences. Information exchanges also included telephone calls and teleconferences with Robert Martin, Paul Mankiewich, and other Lucent/Bell Labs staff members.

Robert Martin also stated via e-mail that he would pass our information to other people in Bell Laboratory's wireless department. Lucent's final communication with Idris was on December 31, 1999, in which Paul Mankiewich stated that he would contact Mr. Alagar the following week in regard to evaluating the relationship between Lucent and Idris. Paul Mankiewich never contacted Mr. Alagar after December 31, 1999, and Lucent did not respond to attempts by Idris Communications to make contact in January 2000. On July 24, 2000, Lucent publicized that it had spun off Flarion Technologies in the second quarter of 2000 to commercialize a seemingly unrelated technology, called "Flash OFDM," based on fast frequency hopping. On September 13, 2000, Flarion filed a provisional patent application (Pat. Appl. No. 60/230,937) claiming similar "innovations" disclosed to Lucent/Bell Labs by Idris Communications. Flarion's filing date indicates the possible awareness of U.S. Pat. No. 5,955,992 since their filing date avoids a statutory bar with respect to the publication of U.S. Pat. No. 5,955,992 by only six days.

Considering the following facts:

- Lucent's Chief Technology Officer received documents describing the subject technology from Idris Communications Inc.
- Documents describing this technology being developed by Idris Communications were passed to the Bell Labs wireless group.
- Rajiv Laroia, an inventor cited on Pat. Appl. No. 09/805,887, held the position of Head of Bell Labs' Digital Communications Research Department in the Wireless Research Center.

It is probable that the inventors cited in Pat. Appl. No. 09/805,887 signed the Oath and Declaration claiming to have invented the subject matter disclosed in Pat. Appl. No. 09/805,887 with the knowledge of U.S. Pat. No. 5,955,992, and other publications provided by Idris Communications.

Very Respectfully,

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